Metal Speciation in Soil, Sediment, and Water Systems via Synchrotron Radiation Research

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Keywords: metal speciation, synchrotron research, bioavailability, remediation, fate, transport
Metal-contaminated environmental systems (soils, sediments, water) have challenged researchers for many years. Traditional methods of analysis have employed extraction methods to determine total metal content and define risk based on the premise that, as metal concentration increases, health risks increases proportionally. While this theory may fit well on a site-specific basis, frequently different sites with similar concentrations of a particular metal have significantly dissimilar impacts on human health and the natural environment. This phenomenon is due to the chemical form or speciation of the metal, which plays a tremendous role regarding the metal's reactivity with its surrounding environment whether in equilibrium or upon perturbation, as well as biological availability. In conjunction with the U.S. Environmental Protection Agency (U.S. EPA)/ORD missions, our research has focused on solving fundamental problems regarding metal speciation in soils, sediments, and water via advanced, molecular-level spectroscopic techniques coupled with macroscopic kinetic and thermodynamic laboratory studies to elucidate reaction mechanisms that influence fate, transport, reactivity, mobility, bioavailability, and toxicity of metals in the natural environment leading to effective and economic remediation strategies. This process of research is unique in which the scope of the investigation ranges from field scale to atomic resolution, providing direct evidence and insight to examine, relate, and effectively answer tough questions regarding the complexity of a contaminated site. The common theme of our research from independent and collaborative efforts is the spectroscopic speciation of metals that affect human health and the environment.

We routinely utilize technically advanced research methodologies and instrumentation in conjunction with bench, pilot, and field analytical laboratory skills. Our synchrotron research at the National Synchrotron Light Source (NSLS) at Brookhaven National Laboratory (BNL) and the Advanced Photon Source (APS) at Argonne National Laboratory (ANL) include the specialized research capabilities of X-ray absorption fine structure (XAFS), X-ray absorption near edge (XANES) [X-ray absorption spectroscopy includes both XAFS and XANES], synchrotron tomography, and X-ray fluorescence (XRF) spectroscopies. The application of synchrotron research within our programs has expanded our complete understanding of metal speciation with respect to fate, mobility, and bioavailability.